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A Limited Test of Solvent Reclamation at an Air Force Flightline Facility

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ENVIRONICS DIVISION
ENVIRONMENTAL ENGINEERING BRANCH

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This report documents procedures and performance of solvent recovery test operations to recycle PD-680 at Tyndall Air Force Base, Florida. An industrial vacuum recovery still was commercially procured and operated to test solvent recycling at a typical Air Force installation. Test operations were conducted over a 24-month period to evaluate a "live-steam" vapor recovery still, and to assess impacts of repetitious recycling on Stoddard solvent (MILSPEC PD-680).

Solvent waste from the Flightline Tire Shop was reclaimed. Nine successive process runs did not fully meet product specification for new solvent. An undetected internal still piping leak was the major cause for not meeting full specification. Point of use performance for reclaimed PD-680 was judged satisfactory by shop personnel, and no appreciable degradation in reclaimed solvent was noted with successive recovery.

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The solvent recovery unit capacity exceeded the quantity of waste stock routinely available for reclamation. Recoverable solvent from small quantity users was limited, resulting in operations dedicated to the tire shop schedule. Rust and scale buildup during periods of nonuse contributed to lacking specification adherence.

PREFACE

This report was prepared by the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida 32403 under Job Order Number 20543036. This report summarizes work accomplished between April 1980 and October 1984. The demonstration project was entitled, "Design, Test and Evaluation of a Small-Scale Solvent Recovery System." Captains Robert G. Blum and Glenn E. Tapio were AFESC/RDVW project officers.

This report documents the combined efforts of numerous Air Force personnel from the concept planning phase, through hardware acquisition, to test operations at Tyndall Air Force Base. While such lead-in tasks are time-consuming and slow in development, the consistent dedication and attention to detail shown by each individual are gratefully acknowledged.

This report discusses the use of a steam-powered distillation unit for reclaiming solvents. The report does not constitute an indorsement or rejection of any specific piece of equipment for Air Force use nor can it be used for advertising a product.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

Solvents play a major role in routine Air Force industrial and equipment maintenance operations. During these operations, the solvent removes grease, oil, wax, and grit from hardware items and becomes contaminated with accumulated impurities. Tank operations require periodic changeout to remove impurities, and to restock with new solvent. Spray and rinse operations generate waste streams which are collected in a sump and processed through an oil-water separator. The waste stock is containerized for centralized turn-in and processing by the local Defense Property Disposal Office (DPDO). Waste solvents are generally segregated by the user, according to principal solvent constituent.

Depending upon solvent waste characteristics and the availability of local vendors, the waste solvent material may be:

1. Sold or recycled as a reclaimable resource,

2. Sold as a low-grade boiler fuel feedstock,

3. Treated in either an industrial or sanitary waste treatment facility, or

4. Disposed of as an industrial or hazardous waste.

The applicability of these options depends upon the waste stream characteristics, waste components, local conditions of waste volume, and nearness of commercial facilities. Ready access to one of the estimated 140 commercial solvent recovery facilities nationwide is not likely with the widely dispersed siting of US military installations (Reference 1). Further, given the intricacies of both federal and state waste management regulations, source definition, reprocessing, and end-use plans for reclaimable materials can be as important in the recovery decision as the obvious economic factors.

This report describes events and activities accomplished by the Air Force Engineering and Services Laboratory at Tyndall Air Force Base, Florida to recover waste solvent material by recylcing. Tyndall AFB was considered a typical size and scope maintenance facility, and solvent use was therefore judged representative of routine Air Force maintenance operations. A test and evaluation project to recycle Stoddard Solvent (an aliphatic petroleum dry-cleaning solvent, military specification PD-680) was begun in 1981. With a goal of determining costs and benefits of onsite solvent recovery, operational data were collected for concept validation and potential extension to other moderate-scale Air Force installations.

SECTION II

BACKGROUND

A. BASE SOLVENT SURVEY

Base supply records were surveyed to identify onbase solvent use data. Records indicated Stoddard Solvent (PD-680, federal stock number 6850-00-285-8011 for drum quantity) as the most-used solvent, with basewide consumption totalling approximately 13,200 gallons per year. Of the 19 using shop activities, the major PD-680 users (with annual consumption by 55-gallon drum lot) were:

Aerospace Ground Equipment (AGE) - 75

Corrosion Control (Wash Rack) - 45

Drone Maintenance - 30

Tire Shop - 26

Jet Engine Shop - 15

Equipment Maintenance Inspection - 11

Transportation Motor Pool - 10

Hydraulic Shop - 8

While PD-680 was commonly used for metal cleaning and degreasing, only the Equipment Maintenance Squadron (EMS) Tire Shop used the solvent in vat or dip tank operations. Tanks were considered favorable due to consistency of waste stream, and sufficient quantity to readily apply reclamation methods. All other base users applied solvents with sprayers or scrubbers, resulting in minimal opportunity to reclaim and recycle concentrated solvent wastes.

A walk-through survey of PD-680 solvent using activities confirmed spray usage patterns. The opportunity to reclaim solvent from skimmers and water-oil seperators was considered minimal without reconfiguring shop operations to accommodate small containment structures to concentrate waste runoff.

A comprehensive usage assessment for other solvents was not undertaken. This assessment would be necessary to formulate an installation-wide activity (Reference 2).

B. SOLVENT RECLAMATION DECISION

Following discussions with the Flightline Tire Shop personnel, several factors were identified which influenced the reclamation decision. Each factor was a positive indication for reclamation, the total of which targeted the Tire Shop as the only favorable location to pursue sustained recovery.

The Tire Shop solvent degreasing operations consisted of two free-standing floor tanks, each of approximately 300-gallon capacity. The tanks contained PD-680 Type II solvent for removing carbon, grease, and grit from aircraft wheel assemblies, and were continuously used until the solvent became sufficiently contaminated to be ineffective. Under routine conditions, the solvent bath was replaced approximately every 12 weeks. Prior to solvent reclamation, the waste solvent was pumped into an appropriate number of 55-gallon barrels, and turned over to the Defense Property Disposal Office (DPDO) for disposal. As a second step, the tank bottom sludge was containerized for disposal.

The Tire Shop supervisor explained that the consistency of arriving parts was very stable, and while work levels fluctuated, the solvent bath conditions remained stable over many weeks. Further, the assessment of solvent bath quality was subjective, and was based solely upon the operator's judgement that the cleaning capabilities were being impared. Finally, the normal operations routine could accommodate a 1-day disruption for solvent recovery.

A proposed recovery plan was drafted for the Flightline Tire Shop. A project was developed to target PD-680 recovery from the Tire Shop, while permitting opportune recovery from other activities. Plans were formalized with the Chief of Maintenance for AFESC to acquire a commercially available solvent reclamation unit to be located at the Tire Shop. After installation and preliminary operations, continuing use of the reclamation unit would be directed by the Tire Shop supervisor, using shop manpower. AFESC would assist in sampling, analysis, and troubleshooting, when needed. Since the Tire Shop operations represented the best opportunity for large quantity recovery, the solvent reclamation unit was located next to the shop (Building 540).

Other base users of PD-680 were contacted and advised of the reclamation initiative. All users were encouraged to segregate PD-860 wastes. The DPDO turn-in point assisted by identifying all PD-680 wastes for transfer to the solvent recovery operation. This requirement was formalized in a base directive, which further encouraged base users to turn-in PD-680 wastes.

SECTION III

RECLAMATION SETUP

A. RECLAMATION EQUIPMENT

The solvent reclamation unit was purchased as a complete system via a multisource procurement action to meet existing requirements at Tyndall AFB. The solvent reclamation unit (See Figure 1) was purchased from Gardner Machinery Corporation of Charlotte, North Carolina. The Unit consisted of a Western-Hilmor vacuum still, with an integrated Reimers Electra Steam boiler, a clarifier tank, and associated plumbing and control accessories. The physical layout and approximate dimensions are indicated in Figure 2.

The contract deliverable requirements included equipment purchase, delivery, installation, and one shakedown process run. Vendor deliverables included the vaccur still, steam boiler, gauges, valves, regulators, a 500-gallon clarifer/settling tank, plus electric and plumbing accessories. The total contract price was $29,500. The $8,500 price for the vacuum still included the steel chamber, heat exchanger, pump, explosion-proof motor, automatic flow regulator, sight gauges, and control valves. Table 1 summarizes cost information.

1. Still. The Western-Hilmor 200 Industrial Still was rated for 200 to 225 gallons per hour solvent recovery from waste stock consisting of 10 to 25 percent oil and grease. The unit stands 86 inches high and requires 35 by 48 inches of floor area. Electric service requirements for the still were 480 volts, 16 amp, three-phase (Reference 3).

2. Boiler. A dedicated steam boiler, Reimers Electra Steam, Model RHP200, rated to 150 psi steam pressure required 45-foot separation for safety considerations. The unit stands 45 inches high, and requires 45 by 70 inches of floor area.

B. SITE DEVELOPMENT

Site development work was accomplished by Air Force personnel before recovery unit installation. Access to electric and water utilities was obtained with an electric meter installed for costing purposes. The installation of a 40 KVA, 240-volt power transformer was a limiting factor because of long delays in procuring the unit. Water supply for the steam boiler and condenser coolant were tapped from existing service lines. Coolant water was spray-applied to nearby yard areas. Concrete pads for the boiler and transformer, with a 1-foot dike to contain the recovery still and tanks, were constructed. The accumulated total cost of site development and utility installation was $20,000.

Figure 1. Solvent Reclamation Unit

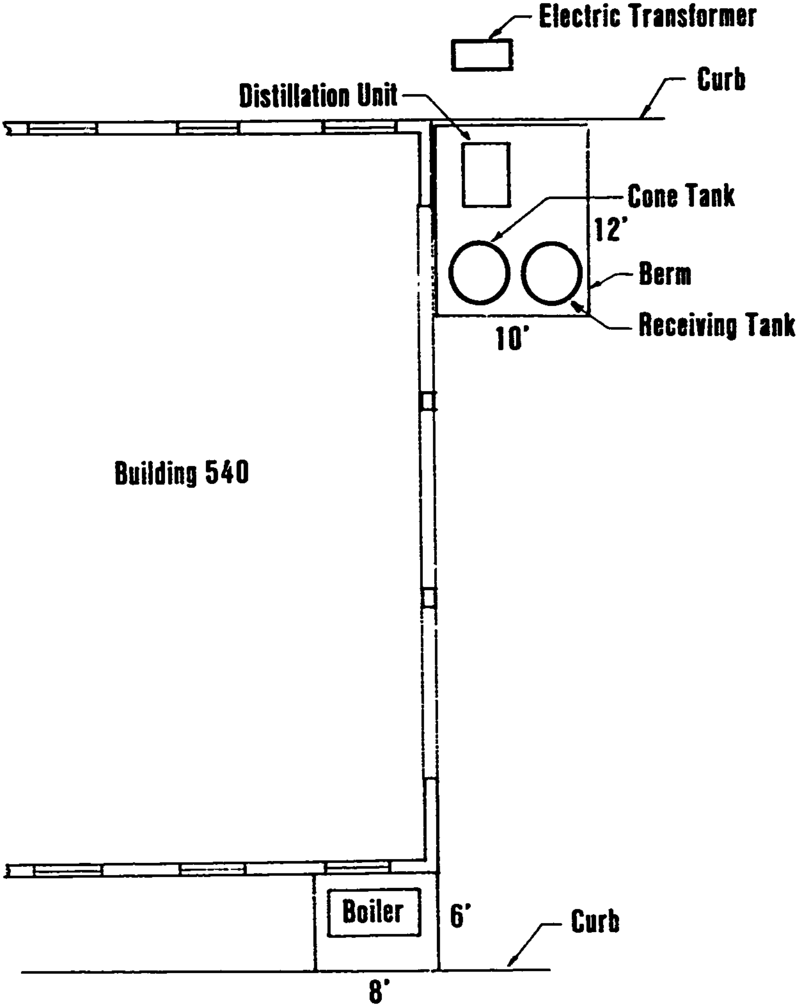


Figure 2. Reclamation Unit Site Layout

TABLE 1. RECLAMATION UNIT AND SITE DEVELOPMENT EXPENSES

Reclamation unit, contract (including boiler, still tank, piping, gauges, shipping, supervising installation, and test run)		$29,500
Installation - Air Force heavy equipment		$ 1,000
Site Development		
Electrical transformer	$7,000	
Electrical material	1,750	
Electrical labor	1,550	
Water System Material	450	
Roof, fence, concrete pad and berm material	4,000	
Roof, etc. labor	2,400	
Miscellaneous material	$1,400	19,000
Total investment expense		$49,500

The reclamation unit was sited out of doors. and two roof extensions were constructed to protect the installed equipment. A privacy fence was also built to limit access to the reclamation unit and control delivery of drummed waste solvent.

SECTION IV

RECLAMATION OPERATIONS

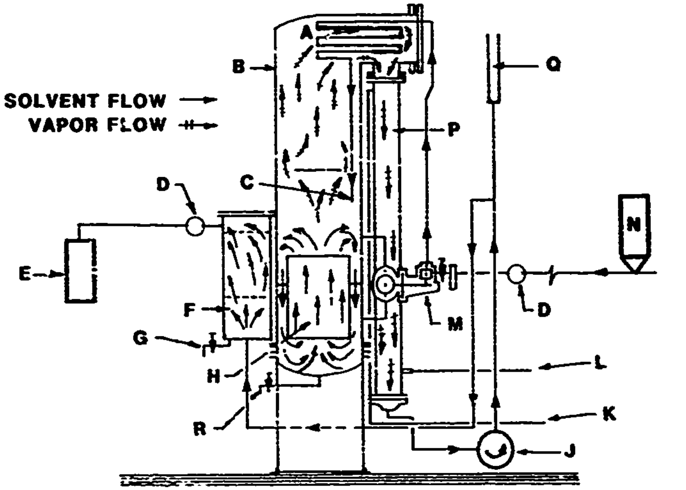
A. PROCEDURES

Solvent recovery was accomplished as a batch process, usually on a Monday, and required constant attention by a system operator. Preliminary actions of boiler warmup, packing cotton rags for water removal, and transferring solvent waste took approximately 2 hours. The processing of up to 600 gallons of waste solvent averaged 4 hours, with an additional 2 hours needed to shut down the still and perform housekeeping chores. While initial operations were accomplished by a two-man crew for safety considerations, the reclamation unit was designed for one-person operation.

To accommodate shop housekeeping, a streamlined waste transfer flow was established. On the Friday before a planned process run, spent solvent was pumped from the two vat tanks into the clarifier/settling tank. Over the weekend, particulate settling into the cone-shaped trap removed the majority of suspended impurities. With the vat tanks emptied, sludge was readily removed and placed in containers for disposal.

To accomplish a process run, preheating the steam boiler was the first action and the 1/2-hour warmup time permitted setting up and checking the remaining equipment. Once the automatic flow control is activated, the boiling vessel (calandria) is filled with waste solvent. The generalized redistillation flow is depicted in Figure 3.

Process steam heats the boiling vessel, which, in turn, heats the waste stock to boiling. The pressure within the still is reduced by a vaccuum pump to approximately 24-26 inches of mercury. By reducing the interior operating pressure, the boiling point of waste stock is similarly lowered, permitting a safer and less expensive still-operating temperature. At this pressure, the boiling point for PD-680 is lowered to 75°-125°F, requiring an operating steam pressure of 30-40 pounds. With the vessel at operating temperature, the still is charged with high-pressure steam ("bumping") to initiate vaporization.



A SUPPLY PREHEATER
B VAPORIZING CHAMBER
C INLET FEED
D SIGHT-FLOW
E DISTILLED SOLVENT RECEIVER
F MOISTURE FILTER
G WATER DRAIN
H STEAM CALANDRIA

J VACUUM PUMP
K COOLANT OUTLET
L COOLANT INLET
M FEED REGULATOR
N CLARIFIER TANK
P CONDENSING COLUMN
Q VENT LINE
R RESIDUE DRAIN

Figure 3. Solvent Recovery Still Schematic

The vapors are subsequently contacted with a series of cooling coils, permitting the condensation of solvent and water. The resulting reclaimed solvent stream flows through a water separator and into a receiving container.

To monitor system performance and assess operating controls, up to four liquid grab samples per process run were collected. Time-series samples were collected at approximate one-third volume intervals, plus one sample from the final solvent blend. Laboratory determination of recycled solvent flashpoint was considered critical to safety and was the only analysis performed at the AFESC laboratory. Detailed analyses were conducted by the MacDill AFB Fuels Laboratory to determine adherence to specification. Routine AFESC flashpoint testing took less than 4 hours, and, if within flash specification, the recycled solvent was released for Tire Shop use. The Fuels Laboratory analysis report took from 2 to 6 weeks to arrive, during which time the recycled solvent was already in use.

The laboratory sample analyses, summarized in Table 2, show inadequate results on most process runs. While full specification requirements were not obtained, recycled solvent parameters were consistently very close. Sustaining Saybolt color was initially attributed to corrosion in the reclamation unit, but was also caused by an undetected internal still leak. The still leak was not detected until the end of the test project.

B. PROBLEMS

1. Comingled Wastes. Two unsatisfactory process runs were encountered during the test period, both of which were caused by comingled waste products. The first run consisted of 300 gallons of DPDO-delivered solvent waste which had been labeled as PD-680 at Eglin AFB, FL. The using organization had applied methylethylketone (MEK) and PD-680 in successive applications, resulting in waste MEK concentration approaching 30 percent. The reclaimed solvent stock exhibited a potentially dangerous flashpoint of 112°F, due to the concentration of highly volatile components. This reclaimed stock was judged unacceptable, and since the vacuum still could not selectively fractionate these volatiles, the entire batch was rejected. The partial batch run was redrummed, and with the remaining solvent waste, was returned to DPDO for disposal.

TABLE 2. REDISTILLED PD-680 SPECIFICATION TESTING RESULTS

	Specification		Analysis Results								
	Type I	Type II	1A	2A	3A	4C	5D	6A	7B	8A	9A
Acidity	Neutral (N)	N	-	-	-	N	N	N	N	-	N
Appearance	--Slight tarnish--		hazy	clear	clear	clear	clear	clear	clear	clear	cloudy*
Corrosion	--	--	1b	1B	1B	1B	1B	1B	1B	good	1B
Distillation											
Initial Boiling Point (°F Min.)	300	350	357	358	352	356	364	360	366	good	365
Fifty Percent Point (°F Min.)	350	375	380	382	376	376	376*	364	382*	good	381*
End Point (°F Max.)	410	415	414	434*	432*	402	414	414	416*	good	435*
Residue Percent (Max.)	1.5	1.5	1.0	1.3	0.9	0.7	0.8	1.0	1.0	good	0.7
Loss Percent	--	--	-	-	-	0.3	1.2	1.0	0.0	-	1.3
Flash Point (°F Min.)	144	138	144	146	140	138	144	115* **	148	142	147
Odor	--	--	-	-	-	sweet	sweet	-	usual	sweet	sweet
Saybolt Color	21	21	12*	-	-	16*	18*	21	10*	14*	12*

* Does not meet specification.
** Reported value contradicts AFESC determination.

The second process run with contaminant limitations resulted from one drum which contained PD-680 tainted with hydraulic fluid. The co-mingling of hydraulic fluid was not detected until the initial flow of reclaimed solvent exhibited strong reddish hue. The initial percentage of hydraulic fluid was unknown, and the dilution factor with 300 gallons of waste PD-680 was estimated at only 1 percent. The still operator determined the red color to be indicative of other unwanted products being present in the reclaimed solvent, and abandoned the process run. The waste solvent was drummed and delivered to DPDO for disposal. No samples were collected.

To minimize the chance of undetected contaminants in solvent wastes, a procedure to visually check a stratified sample from each drum of delivered waste solvent was begun. A 1-inch diameter glass tube, approximately 40 inches long was lowered into each settled drum of waste. A rubber stopper was used to cap the exposed end, and a quick scan of the extracted sample revealed any immiscible or colored contaminants. Likewise, a quick odor check confirmed the sweet characteristic aroma of PD-680.

2. Plumbing. A pipe connection at the top of the condensing column temporarily caused some operating difficulty. The hazy appearance of reclaimed solvent at the initiation of the sixth process run indicated a cross connection. All external piping was checked and found to be intact. Flow indication suggested that overflow from the calandria, backing up and spilling into the condensing column was not likely. The most probable cause was a failed pipe or connection inside the still. An inspection plate at the top of the condensing column was removed, and a visual check revealed that a pipe joint had worked loose. Due to the piping location, the simple taping and tightening task took 2 hours to accomplish. This action corrected the problem.

At the conclusion of the testing period, the still was partially dismantled for inspection of the internal mechanisms. It was during this inspection that a flawed weld in the waste solvent supply preheater was discovered. The flaw resulted in a small, but continuous, crossfeed of waste solvent into the re-distilled solvent condensing column. The preheater is a heat exchanger which cools the distilled solvent vapors by warming the incoming waste solvent stream prior to the calandria. This leak was a major contributor to induced color and turbidity in recovered solvent and contributed to still pressure fluctuations.

While a detailed inspection of internal items would not be feasible during unit acceptance, a special pressure testing for air leaks could likely have uncovered this condition, and is therefore suggested as a quality assurance measure in similar activities.

SECTION V

COST/BENEFIT EVALUATION

The summary of PD-680 recovery operations at Tyndall AFB is presented in Table 3. The frequency of recovery operations was dictated by changeout of spent solvent from the Tire Shop. Waste solvent turn-in from small volume users was infrequent, and amounted to less than 250 gallons per year. This turn-in consisted of drummed wastes, the contents of which were mixed with Tire Shop wastes. Prior to reclamation, the drummed waste was permitted to stand undisturbed for particle settling a minimum of 2 days. Then the liquid contents were pumped into the large clarifier tank with an explosive-proof barrel pump. Any drum residue was turned in to DPDO, labeled according to generating shop instructions.

The accumulated reclamation unit and site development expenses are presented in Table 1. The contract deliverable cost of $29,500 represents the reclamation unit in total. The $20,000 site development expenses were estimated using Air Force shop rates. The total maintenance expenses for 24 months of operations was $1,300.

The value of reclaimed solvent depends upon five factors:

1. Purchase price of new solvent,

2. Deferred income via DPDO for vendor purchase of waste materials usable as a fuel stock,

3. Manpower required for reclamation processing,

4. Disposal of still-bottom sludge as a hazardous waste,

5. Electric power for reclamation processing.

The purchase price of PD-680 proved to be quite variable, and directly impacted the economic payback profile. Prices for new stock PD-680 per gallon were quoted as:

March 1982	$4.51
August 1982	$2.30
January 1983	$1.97

TABLE 3. TYNDALL AFB SOLVENT RECOVERY OPERATIONS.

PROCESS RUN	1	2	3	4	5	6	7	8	9
Waste Input, Gallons	500	350	440	700	475	550	540	550	700
Reclaimed Solvent Gallons	455	315	410	650	460	510	510	520	650
Percent Reclaimed	91	90	93	97	97	93	94	95	93
Still Residue	45	35	30	50	15	40	30	30	50
Electric Use, Kw Hours	Est. 210	Est. 200	250	230	210	240	220	220	240
Manhours	8	7	3	8	6	7	8	7	8

September 1983	\$2.22
May 1984	\$2.02

The cost factors are presented in Table 4. With the exception of new purchase price, the cost factors were stable. The value of reclaimed PD-680, based upon the September 1983 price of \$2.22 per gallon of new solvent, is \$1.60 per gallon. The same analysis, at a May 1984 updated price of \$2.02, reflects a reclaimed PD-680 value of \$1.40 per gallon. Thus, each gallon of recycled PD-680 avoids purchase costs, and generates an income flow to partially offset recovery unit operating expenses.

A simple averaging of operating and payback profiles is presented in Table 4. The breakeven analysis details have been rounded, and do not account for the time value of funds. Based upon a reclamation unit capacity of 440 gallons reclaimed solvent per process run, the number of process runs to breakeven operations can be estimated. For Tyndall AFB operations, accounting for no significant changes, breakeven operations would oocur after 14 years (31,250 gallons divided by 2,240 gallons per year). At a facility with a greater quantity of reclaimable solvent, the payback period would be shortened. Solvent reclamation at a rate approaching 16,000 gallons per year would result in breakeven operations after 2 years.

The payback profile based upon the number of recovery process runs is encouraging. However, for Tyndall AFB sustained operations, a 14-year period is not econmically justified. Thus, the recovery operation was oversized for solvent usage patterns at the Flightline Tire Shop and various small quantity users. The economic justification for locally performing solvent recovery directly hinges upon the quantities of waste solvent available for reclamation (Table 5).

The local circumstances of hazardous waste disposal will likewise impact reclamation economics. The expenses associated with any permitting process must be taken into account. Further, benefits in the form of relief from regulatory provisions due to status of reclaimed or recoverable material, as opposed to hazardous waste, may have significant ramifications. A detailed assessment of these definitions and point-of-use specifics should be accomplished before any final decisions are made.

TABLE 4. SOLVENT RECOVERY COST FACTORS

Purchase avoidance at \$2.22 per gallon	\$9,946
Deferred DPDO income at \$0.321 per gallon	- (\$1,438)
Processing manpower at \$13.51 per hour	- (\$ 905)
Sludge disposal at \$1.00 per gallon	- (\$ 325)
Electric consumption at \$0.055 per kilowatt-hour	- (\$ 111)
	\$7,167

NOTE: Resultant dollar value of reclaimed solvent is \$1.60 per gallon, based upon 4,480 gallons reclaimed PD-680.

TABLE 5. ESTIMATED SOLVENT RECOVERY BREAKEVEN COST ASSESSMENT

Fixed/Sunk Costs	Value of reclaimed solvent, per gallon	Reclaimed solvent quantity to break even, gallons	Number of process runs, 440 gallons each
$50.000	$1.60	31,250	71
	$1.40	35 715	81
	$1.20	41,667	95

NOTE: Does not account for time value of funds.

The near perpetual recycle capabilities of PD-680 are worth noting. With the PD-680 military specification, based upon performance characteristics, repeated reclamation is possible. Due to minimal content requirements, no chemical controls or additives are needed. Therefore repeated cycling of the same stock from dip tanks to reclamation unit and back to dip tanks, is possible. This continual recycling was demonstrated with no degradation in solvent properties. With an average process volume loss of only 7 percent, the consumption of new PD-680 at the Tyndall Tire Shop dropped from an average of 26 to 3 drums per year.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

The limited-scale solvent recovery initiative at Tyndall AFB covered a period of 3 years. The information, gathered from nine successive recovery process runs during 24 months, documents the performance of a "live-steam" solvent recovery still, and the operational difficulties encountered.

The solvent recovery initiative accomplished repetitive recovery of PD-680 at Tyndall AFB. The operations and maintenance data collected are applicable to forecasting cost recovery factors for other installations. Further, the assessment methodology provides a logical framework upon which the decision for onsite recovery can be based.

The testing of solvent recovery equipment demonstrated acceptable use and maintainability of such systems. Constant attention to process operations by an experienced operator was required. While steam boiler recharge and batch release of waste solvent into the still were automatically regulated, monitoring and regulating of steam pressure was a continual task. Inspection of sight gauges and process controllers was also needed. The operator had to be familiar with the reclamation equipment and the process control features to maintain the vacuum still essential operating parameters.

While still performance was less than ideal, the results of recovered solvent usage were consistently satisfactory. Continual failure to meet full specifications for new PD-680 solvent probably resulted from a flaw in the internal piping of the still condensing column. A defective weld was found after still teardown, which had permitted small quantities of waste stock to continually enter the condensate tower, and subsequently cross feed into the reclaimed solvent stream. Secondary factors for lacking performance were piping rust, scale, and internal piping corrosion, which built up during extended periods of disuse. These further contributed to poor color and appearance characteristics. Due to the predominant impact of the internal leak, the relative contributions of process control and operator skill could not be quantified.

Two process recovery runs were abandoned due to unacceptable presence of contaminants. One process run was contaminated with up to 30 percent methylethylketone, which was not isolated during the distillation process. Another process run was tainted by an unknown quantity of hydraulic fluid. The red color in the reclaimed solvent being indicative of persistent contaminants, the process run was terminated.

B. MAINTENANCE

Recurring maintenance of the recovery unit was required. Close inspection of fittings, gauges, and seals was essential to maintain operating vacuum conditions. Numerous seals and packing materials deteriorated during the performance period and were readily replaced. Infrequent "blow-downs" of the steam boiler and the steam calandria were performed according to manufacturer recommendations.

The exterior siting of the recovery still and boiler compounded system maintenance. During two winters, freezing of water in piping traps and joints resulted in ruptures. These maintenance expenses totaled $700 in material and $600 in labor, which could have been avoided had the reclamation unit been sited indoors.

A secondary benefit of onsite reclamation was encountered in early 1983. A lapse in solvent supply contracts resulted in a PD-680 shortage in Air Force supply channels. With the dedicated reclamation unit, the Tyndall Tire Shop was not affected by the supply disruption.

C. EXPANDED APPLICATION

While reclamation opportunities at Tyndall were limited by PD-680 waste material available for recovery, only minimal improvement, in cost factors would be expected for down-sizing industrial "live steam" equipment. That is, a similar unit with 50 percent capacity, would likely result in only a 20 percent cost reduction.

However, new designs and improvements in process automatic controllers have made significant inroads in this application. Sized units, which incorporated electric heating elements sealed within the calandria, permit recovery without the need for process steam. Coupled with a self-regulating feed mechanism, these improved reclamation units permit efficient, unattended operations with less expensive site development.

These improved reclamation units simplify the necessary procedural steps for solvent recovery and require only a visual check prior to activating the process controller. At the termination of a run, the unit automatically shuts down. After a cooling period, still sludge must be removed before further solvent recovery. Such a unit has been installed at Warner Robins Air Logistics Center, and operations to date are reportedly very impressive.

Given both the expense associated with supplying process steam to this "live steam" still, and the associated problems encountered with process control, this class of traditional reclamation equipment should be considered only for those locations where experienced manpower can be readily available to operate and maintain the equipment.

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